PATENT
5858-01900 SR 2000/20 US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No. 10/787,432
Confirmation No. 4755

I hereby certify that this correspondence is being transmitted to the United States Patent & Trademark Office via electronic submission or facsimile on the date indicated below:

05/20/2008 /Pamela Gerik/
Date Pamela Gerik

DECLARATION UNDER 37 C.F.R. 1.131

Harry Schilling and Georg Lohr, hereby declare and state that:

1. We are the named co-inventors in the above-identified U.S. Patent Application, Serial No. 10/787,432, filed February 26, 2004.

2. We have been informed that in the present application, certain claims have been rejected on reference to U.S. Patent No. 7,072,289 to Yang et al. (hereinafter "Yang"), issued July 4, 2006 and filed on June 1, 2001.

CONCEPTION

3. As set forth in more detail below, we conceived the subject matter claimed in the present application before June 1, 2001. The subject matter involves the suppression of electromagnetic interference (EMI) during transmission of digital signals. Pseudo random or random values placed within idle periods in which no digital signals are present improve electromagnetic compatibility. Gaps between spectral lines are substantially reduced, and amplitudes of the spectral lines are decreased. Inserting pseudo random or random values in idle periods between

which digital signals are present is particularly suited in computer tomograph (CT) scanning, where idle periods of no data transmission can be relatively long.

4. Exhibit A attached hereto is a true and correct copy of a document written by ourselves, and submitted to our employer, Schleifring und Apparatebau GmbH, assignee of the above-identified U.S. Patent Application. At the bottom of each page of this document is a date corroborated by us as a correct date in which we created the document, and that date is before June 1, 2001. The actual date from the bottom of each page has been redacted from Exhibit A.

5. Exhibit A describes and illustrates the presently claimed features of a data communication system having a first unit transmitter and a second unit receiver (Exhibit A -- pp. 1 and 2); a pseudo random or random generator for generating pseudo random or random patterns (Exhibit A – pp. 3 and 4); wherein the pseudo random or random patterns can be inserted into the static/idle patterns in which the transmitters are not sending valid data (Exhibit A -- pp. 4, 5 and 6). Test results of my invention are shown in Exhibit A, associated with spectrum measurements, were also used in the above-identified U.S. Patent Application (Exhibit A -- Figs. 8, 9, 10, and 12).

REDUCTION TO PRACTICE AND DILIGENCE

6. As set forth in more detail below, we began testing our invention set forth in Exhibit A to ensure it would work for its intended application and purpose. Shortly after completing our initial idea described in Exhibit A, we set experiments, simulation bench tests, laboratory mock ups, and actual device interoperability testing to validate our ideas would operate no only in hte laboratory but also in the field.

7. Exhibit B attached hereto is an internal correspondence memo in German language, in both the original German language and translated by me (Georg Lohr) to English, from Kurt Dolhofer, president of Schleifring und Apparatebau GmbH, dated October 17, 2000, indicating

that our employer has taken ownership of our invention and to allow us to continue research and work on our ideas.

8. With adequate funding, we worked diligently on our ideas, experimenting, testing, and modifying some operability of our invention beginning at the time of our conception, throughout the fourth quarter of 2000 and into the first and second quarter of 2001. We made various changes to our invention in order to ensure its operability in accordance with Exhibit A, primarily in the computer tomograph (CT) field. Testing and experimenting continued as we discovered certain unique problems associated with EMI in the CT field. More testing and experiments were run on several CT machines as those machines were made available to us, beginning in late 2000 through the date our invention was approved for drafting a patent application and when a German Patent Application 101 42 102.8 was filed on August 30, 2001. Thereafter an International Patent Application was filed as PCT/DE02/03024 on August 19, 2002 designating the United States and claimed priority to German Patent Application 101 42 102.8. Thereafter the captioned U.S. Patent Application was filed claiming priority to International Patent Appliation No. PCT/DE02/03024.

9. We continued working on, testing and generally increasing certain functionality of our invention throughout the critical time period extending from a time just prior to June 1, 2001 through the date in which German Patent Application 101 42 102.8 was filed. We did not abandon, suppress, or conceal the ideas set forth in the claimed invention during at least the time beginning prior to June 1, 2001 through the date of constructive reduction to practice on August 30, 2001.

10. We were duly diligent during the critical time period extending from a time just prior to June 1, 2001 through the date of constructive reduction to practice, and we continued to work on the ideas set forth in Exhibits A and B by building, testing, experimenting with, and generally improving the operation of the invention throughout the critical period. After performing the mental steps required to conceive the invention, the inventive concepts were simulated, bench tested and proved functional on various models of CT scanners, as well as other devices.

11. Upon information and belief, it is my informed understanding that diligence in reducing the invention to practice was, therefore, maintained from prior to June 1, 2001 through the date of constructive reduction to practice of our invention on August 30, 2001.

12. We hereby declare that all statements made herein of our own knowledge are true and that all statements made herein on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 22.04.2008 ______________________
Harry Schilling

Date: 27.04.2008 ______________________
Georg Lohr

Exhibit A

1 Frequency Spectrum of Digital Signals

As in almost every digital data link the data stream is in PCM format, which means there are only two digital levels, zero and one. The information is contained in the presence of zeroes or ones in specific time slots. For a signal with alternating zeroes and ones the waveform looks like a symmetrical square wave (Fig. 1) with a frequency that is half the bit clock rate.

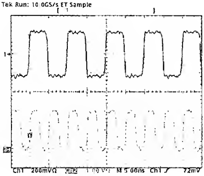

Fig. 1: 200 MBaud 1010 PCM signal (upper trace) and bit clock (lower trace)

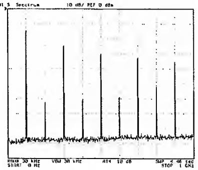

Fig. 2: 200 MBaud 1010 PCM signal spectrum 0...1GHz.

Such a signal has the well-known spectrum, which is shown in Fig. 2.
There are only odd harmonics with linear decreasing amplitude. Even harmonics appear only, if the signal is unsymmetrical. When the signal has other patterns with larger time intervals of

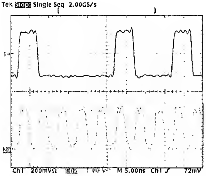

Fig. 3: 200 MBaud PCM signal with 10000100 pattern (upper trace) and bit clock (lower trace).

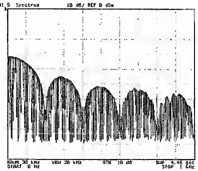

Fig. 4: 200 MBaud PCM signal (10000100) spectrum 0...1GHz.

zeroes or ones like the signal in Fig. 3, then in the spectrum appear side bands with offsets of

1.1 Common Data Encoding Schemes

Usually data is packaged into frames which contain additional frame and error checking bits [6]. These additional bits are also necessary to synchronize the data receiver to the transmitter. Often some specific encoding like 8B/10B is used to perform these tasks. So an extremely long data stream consisting only of zeros or ones would never appear. Typical frames containing synchronization and error correction bits have sizes n_{Frame} of about 10 to 20 bits. This gives a lower frequency limit and spectral line spacing at the frame repetition rate, even if the data contain only zeroes or ones. With a data clock rate f_{Data} the lower frequency limit f_{Min} and the minimum spectral line spacing is

$$f_{Min} = \frac{f_{Data}}{n_{Frame}} \tag{1}$$

In addition data is usually encoded to be DC-free and to increase redundancy for simple error detection. Both, data packaging and encoding helps spreading up the spectrum. The small package size gives a relatively high package repetition rate and therefore a moderate spectrum spreading effect. For example a 10 bit frame gives at a data clock rate of 200MHz a spectral line spacing of

$$f_{Min} = \frac{200MHz}{10} = 20MHz \tag{2}$$

This means that in the spectrum appear not only spectral lines at 100MHz, 300MHz, 500MHz, etc. but additional lines spaced at 20 MHz. This gives five times more spectral lines with an average decrease of 7dB in power. Such an encoding alone is not good enough for an efficient EMI suppression.

1.2 Pseudo Random Patterns

A data stream having a random sequence of zeroes and ones gives a very even spectral distribution. Theoretically an infinite random sequence will cause a perfect spread spectrum with constant spectral power density. Unfortunately such a data stream cannot contain the desired information. To solve this problem deterministic pseudo random patterns can be used. These consist of a predetermined, reproducible sequence of bits. Usually the length of these patterns is fixed. These pattern are called pseudo random patterns because at the first glance they look like a random sequence but they have a fixed sequence and can be predicted. A real random sequence never can be predicted.

1.2.1 Influence of Pattern Length on Spectral Density

Practically used pseudo random patterns have a limited pattern length. After transmitting n_p bits the same pattern is repeated. The reasons for short patterns are limited storage for the pattern and easier synchronization. A long pattern and therefore a low pattern repetition rate result in low frequency components in the signal and therefore in a close spectral line spacing. The minimum distance Δf of adjacent spectral lines is inversely proportional to the random pattern length n_p.

$$\Delta f = \frac{f_D}{n_p} \qquad (3)$$

So a large pattern length is desirable for a low spectral line spacing. The influence of pattern length is shown in Fig. 5, Fig. 6 and Fig. 7.

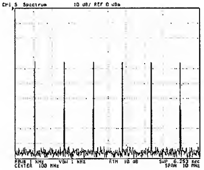

Fig. 5: 200 MBaud PCM PN7 Spectrum (pseudo noise with 128 bit pattern length); peak amplitude is -36 dBm and line spacing is 1.56 MHz.

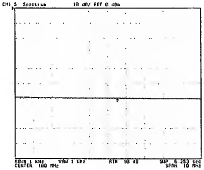

Fig. 6: 200 MBaud PCM PN15 Spectrum (pseudo noise with 32768 bit pattern length); floor is –60 dBm and line spacing is 6.1 kHz.

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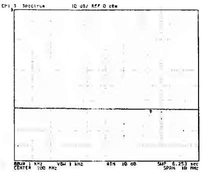

Fig. 7: 200 MBaud PCM PN17 Spectrum (pseudo noise with 131072 bit pattern length); floor is at -54 dBm and line spacing is 1.5 kHz.

In Fig. 5 the spectral lines are spaced at 1,56 MHz, their amplitude is –36dBm. When a longer code sequence is selected as in Fig. 6 where the pattern length is 256 times longer then the spectral lines are spaced at 6.1 kHz. This is below the resolution of the spectrum analyzer which displays a straight line. The amplitude of the spectral lines (which is identical to the amplitude of the linc) is with –60 dBm exactly 1/256 of the previous amplitude of –36 dBm. A four times longer pattern length is applied in Fig. 7 resulting in a 4 times lower (-6 dB) signal amplitude.

1.2.2 State of the art application of pseudo random patterns

A simple approach for very short pseudo random scquences is a coding scheme like the common used 4B/5B or 8B/10B encoding [1]. Here 8 bit binary numbers are encoded into a sequence of 10 changing bits. So even a 0 will not result in a long sequence of zero bits. These patterns have a slight spreading effect as described in chapter 1.1 but give a more even spectral distribution.

Furthermore a very common use of pseudo random patterns are bit error rate tests where the broadband spectrum of these pattern permit a thorough test of the whole transmission system.

1.3 Static Patterns

Most serial transmitters use an idle signal when there is no data to be transmitted. This idle signal is a unique pattern which permits identification as „no data" and helps the receiver to be synchronized to the transmitter clock. Usually there is only one type of idle pattern. When no data is transmitted over long periods of time then only this pattern will be sent over the link. It has the same length as a standard data word and therefore a comparatively high lower frequency and spectral line spacing which is given by equation (5). Usually such patterns do

not have an even distribution of their spectral lines. As a consequence a high speed data link can have excellent EMI characteristics when real data is transmitted. But in the moment when transmission stops and an idle signal is transmitted the EMI performance is very poor. These static patterns are the worst case for electromagnetic emission. If transmission of these patterns cannot be avoided over longer periods the EMI measurement should be conducted under this condition.

In a good system design such static patterns should be avoided under any circumstances. This can be done by sending varying customer idle signals or by sending a pseudo random sequence which signals the idle state. Even a long sequence of 0 codes can be accepted if it is encoded with a pseudo noise signal with a long pattern length (chapter 3.1).

2 Influence of a Spread Spectrum on EMI Performance

The general term EMI-performance is very difficult to define. This document refers to the very common standard CISPR 11. This standard gives limits for the maximum emission of electromagnetic energy and cites the appropriate measurement procedures. This standard specifies a measurement for radiated emissions in the frequency range of 30 MHz to 1 GHz. Radiated power is measured at 120 kHz steps with 120 kHz bandwidth. When applying any spectrum spreading technique, it is not absolutely necessary to have an even distributed broadband spectrum, it is only necessary to take care that every 120 kHz slot gets the same energy. This can be achieved by broadband signal or single narrowband peak in that slot. For most applications spreading up this spectrum in lines which are in a distance of 120 kHz or with some safety margin 100 kHz of each other is the most economic solution. Further spreading of this spectrum requires introducing very low frequency changes in the data stream. In some applications these changes occur naturally when real world data like video are transmitted. But care should be taken that in extreme situations, when i.e. the video signal is off and only digital zeroes are transmitted, the spectrum is spread wide enough to meet the EMI regulations.

Kommentar [Lo1]: Stimmt das ?

3 Methods for Spreading up Bandwidth

As we have seen before there are different ways for spreading up the spectrum. The best effect on electromagnetic emission is obtained when at least two methods, complementing each other, are applied. A very good combination is a pseudo noise data encoding together with some kind of data timing modulation. Data timing can be modulated in different ways. One way is to modify the original data clock at the transmitter. Another way is to modify the timing of the data stream itself.

3.1 Data Encoding

As shown in the last chapter for optimum EMI performance the data stream should look like a random sequence. Very often real world data has random characteristics. In measurement

signals or video images, there is always some noise which introduces the random characteristics. In other cases coding the data stream with a random sequence would bring a desired result. This coding can be done very easy. If data is transmitted in big blocks, each block could be XORed (exclusive or) with a given random sequence (Fig. 8). Now the transmitted signal looks like a random signal. Even in the worst case of a sequence of zeroes or ones the signal looks like a random signal.

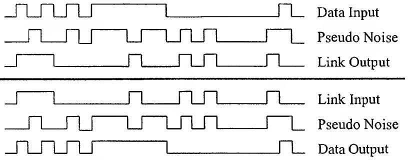

Fig. 8: Random encoding (upper three traces) and decoding (lower three traces). Encoding is done by applying the exclusive or function to the data and a pseudo noise sequence.

The receiver can reconstruct the original data by XORing the block with the same random sequence as the original data block. As an alternative the signal could be fed into a classic pseudo random generator which can be based on shift registers with feedback [4].

There are special situations which should be taken care of. Most data serializers have a fixed 'no data' signal which helps them to synchronize in the case of lack of data. If the serializer gets no data it will continuously transmit this short data word, which usually consists of a sequence of 10 to 20 Bits (Chapter 1.3). This signal gives a very wide frequency line spacing and therefore very poor EMI characteristics. So under any circumstances it must be prevented a static pattern to be transmitted. To prevent this the serializer must be fed with data. This can be done by a simple software change. Instead of sending no data there could be sent the same blocks which are used for data but filled with zeros or some other pattern which can be identified as no data. When the stream of zeros is XORed (exclusive or) by the random pattern, it gives a perfect random pattern at the data link and therefore best EMI-performance. At the receiver after XORing the random pattern the stream of zeros can be easily identified as no data.

As shown in chapter 1.2.1 the spectral line distance is inverse to the pseudo random pattern length. The minimum spectral line distance can be calculated by equation (3). To complement data encoding some timing modulation technique should be used. Unless very long code

3.2 Measurements of Modified Digital Signals

Some final measurements show the benefits of a spread spectrum PCM signal. In Fig. 9 a worst case 1010 PCM signal at 200 MBaud is shown. Here the peak amplitude is –14.7 dBm at 100 MHz. When a real 8B/10B encoded signal is applied, the spectrum looks like Fig. 10. Now in this example the maximum amplitude is –20.6 dBm and the minimum distance of spectral lines is 20 MHz. Due to the short length encoding this spectrum is not evenly spread. It has no constant power density, which would be desirable, but some peaks with zeroes in between. But even this brings an improvement of about 6 dB over the 1010 worst case signal.

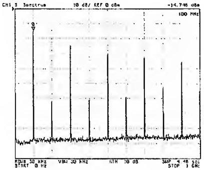

Fig. 9: 200 MBaud 1010 PCM signal spectrum 0...1GHz.

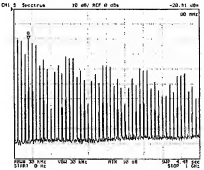

Fig. 10: 200 MBaud 1010 PCM signal spectrum with 8B/10B encoding 0...1GHz.

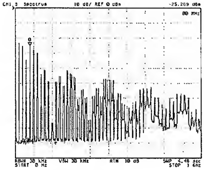

Fig. 11: 200 MBaud 1010 PCM signal spectrum with 8B/10B encoding and FM 0...1GHz.

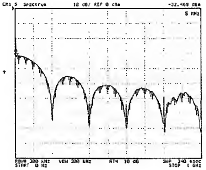

Fig. 12: 200 MBaud 1010 PCM signal spectrum with pseudo noise encoding 0...1GHz.

When a frequency modulation is applied to the 8B/10B signal it results in the spectrum of Fig. 11. Now the maximum amplitude is –25.3 dBm with again 5 dB improvement. Here the frequency modulation only fills the gaps between the 8B/10B signal spectral lines but it cannot flatten the spectrum. A long pseudo noise sequence encoding with a pattern length of 128 bits gives a very even spectrum with a maximum amplitude of –32.5 dBm as shown in Fig. 12. The measured values prove the theoretical considerations. Some deviations are caused by limitations and simplifications of the theoretical model.

4 Summary

When using high speed digital data links considerable care must be taken to meet the requirements of international EMI regulations. With data rates of some hundred to several thousand kBaud the fundamental frequency is in the range of common communication, radio and tv-bands. To reduce interference in general it is better to transfer the information with a broadband signal with even distributed low spectral power density instead of having some discrete high power spectral lines.

This document describes how common used digital data links can be modified in such a way that the spectrum is spread up significantly.

There are two complementing methods to achieve this. The first method is appropriate encoding of the digital signal. The other method is a kind of frequency modulation. This frequency modulation can be done anywhere in the link without affecting transmitter or receiver.

References

[1] "HOTLink™ Transmitter/Receiver Datasheet CY7B923/CY7B933", Cypress Semiconductor Corporation, USA, 1997, pp 7, 23.

[2] "TAXIChip™ Integrated Circuits Transparent Asynchronous Transmitter/Receiver Interface Am7968/Am7969 Data Sheet and Technical Manual", Advanced Micro Devices, Inc., USA, 1994, p 59.

[3] "Low Cost Gigabit Rate Transmit/Receive Chip Set with TTL I/Os"; HDMP-1022 Transmitter, HDMP-1024 Receiver Data Sheet, Hewlett Packard Co., USA, 1997

[4] Dorf, Richard C., "Electrical Engineering Handbook", CRC Press, 1993, p 1599.

[5] De Vito, Lawrence, "A Versatile Clock Recovery Architecture and Monolithic Implementation", Monolithic Phase-Locked Loops and Clock Recovery Circuits, IEEE Press 1996, p 405.

[6] Irwin, David J., "Industrial Electronics Handbook", CRC Press, 1997, p 394.

[7] Meinke, Gundlach, "Taschenbuch der Hochfrequenztechnik", 5. Auflage, Springer Verlag, Berlin, 1992, p O13.

SCHLEIFRING

SCHLEIFRING und APPARATEBAU GmbH

Herrn
Dr. Georg Lohr
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Exhibit B

17.10.00
KDR/ck

Ihre Erfindungsmeldung vom [redacted] (Nr. NT 136)
‚Störarme Signalübertragung'

Sehr geehrter Herr Dr. Lohr,

hierdurch teilen wir Ihnen mit, daß wir Ihre Diensterfindung, die Sie uns unter oben genannter Nummer gemeldet haben, **unbeschränkt** in Anspruch nehmen (§§ 6, 7 Abs. 1 ArbNErfG).

Mit dieser Erklärung gehen alle Rechte an dem Erfindungsgegenstand auf uns über.

Wegen der Höhe der Ihnen zustehenden Erfindervergütung werden wir unmittelbar mit Ihnen in Kontakt treten, wenn eine Verwendung Ihrer Erfindung erfolgt oder ein Schutzrecht erteilt worden ist.

Mit freundlichen Grüßen

Kurt Dollhofer

Kurt Dollhofer
Geschäftsführer

19.10.00

Your report of an invention dated [redacted]
"Interference-free Signal Transmission"

Dear Dr Lohr:

You are hereby informed that we make an **unlimited** claim to your service invention that you have reported to us under the above-indicated number (Paragraphs 6, 7, Section 1 of the Law on Employee Inventions).

With this declaration, all rights to the subject matter of the invention are assigned to us.

Concerning the amount of inventor's compensation due to you, we will contact you immediately when use is made of your invention, or a protective right has been granted.

Yours sincerely,

(signed) Kurt Dollhofer

Managing Director